TS39301/2/3/4

3A Ultra Low Dropout Positive Voltage Regulator

TO-220-5L

TO-263-5L

Low Dropout Voltage 0.4V (typ.)
Output Current 3A
Low Quiescent Current

General Description

The TS39301/2/3/4 are 3A ultra low dropout linear voltage regulators that provide low voltage, high current output with a minimum of external components. The TS39301/2/3/4 offers extremely low dropout (typically 400mV at 3A) and low quiescent current (typically 36mA at 3A).

The TS39301/2/3/4 is ideal for PC add-in cards that need to convert from standard 3.3V to 2.5V or 2.5V to 1.8V. A guaranteed maximum dropout voltage of 500mV over all operating conditions allows the TS39301/2/3/4 to provide 2.5V from a supply as low as 3V, and 1.8V from a supply as low as 2.5V. The TS39301/2/3/4 also has fast transient response for heavy switching applications. The device requires only 47uF of output capacitor to maintain stability and achieve fast transient response.

On the TS39301/2/3/4, the enable pin may be tied to input voltage if it is not required for enable control. This series are offered in 5-pin TO-220, TO-263 package.

Features

- ✧ Dropout voltage typically 0.4V @Io=3A
- ✧ Output current up to 3A
- ✧ Low ground current
- ✧ Current limiting and Thermal shutdown
- ✧ Extremely fast transient response
- ✧ Reversed leakage protection
- ✧ Reverse battery protection
- ✧ TTL/CMOS compatible enable pin
- ✧ Error flag output (TS39301 only)
- ✧ Adjustable version (TS39302 only)
- ✧ Output voltage sense (TS39303 / 4 only)

Ordering Information

Part No.	Operating Temp.	Package
TS39301CZ5**xx**	-40 ~ +125 °C	TO-220-5L
TS39302CZ5		
TS39303CZ5**xx**		
TS39304CZ5**xx**		
TS39301CM5**xx**		TO-263-5L
TS39302CM5		
TS39303CM5**xx**		
TS39304CM5**xx**		

Note: Where **xx** denotes voltage option, available are

50 = 5.0V
33 = 3.3V
25 = 2.5V
18 = 1.8V

Applications

- ✧ Battery power equipment
- ✧ LDO linear regulator for PC add-in cards
- ✧ PowerPC™ power supplies
- ✧ Multimedia and PC processor supplies
- ✧ High efficiency linear power supplies
- ✧ High efficiency post regulator for switching supply
- ✧ Low-voltage microcontrollers and digital logic
- ✧ SMPS post regulator

Absolute Maximum Rating (Note 1)

Supply Voltage	Vin	-20V ~ +20	V
Enable Voltage	Ven	+20	V
Storage Temperature Range	T_{STG}	-65 ~ +150	°C
Lead Soldering Temperature (260 °C)		5	S
ESD		(Note 3)	

Operating Rating (Note 2)

Operation Input Voltage	Vin (operate)	+2.5 ~ +16	V
Operation Enable Voltage	Ven (operate)	+16	V
Power Dissipation (Note 4)	P_D	Internally Limited	W
Operating Junction Temperature Range	T_J	-40 ~ +125	°C

Electrical Characteristics

(Vin = Vout + 1V, Venable= 2.4V, Tj = 25 °C, unless otherwise specified.)

Parameter	Conditions		Min	Typ	Max	Unit
Output Voltage	I_L=10mA		0.990|Vo|	5.0 / 3.3	1.010|Vo|	V
Output Voltage	10mA ≤ I_L ≤ 3A, Vo+1V ≤ Vin ≤ 8V		0.980|Vo|	2.5 / 1.8	1.020|Vo|	
Line Regulation	I_L=10mA, Vo+1V ≤Vin≤ 8V		--	0.06	0.5	%
Load Regulation	Vin=Vout+1V, 10mA≤I_L≤3A		--	0.2	1.0	%
Output Voltage Temp. Coefficient	(Note 5)		--	40	100	ppm/°C
Dropout Voltage (Note 6 & 8)	ΔVout= -1%	I_L=100mA	--	65	200	mV
		I_L=750mA	--	185	--	
		I_L=1.5A	--	250	--	
		I_L=3.0A	--	400	550	
Quiescent Current (Note 7)	Vin=Vout+1V	I_L=100mA	--	6	10	mA
		I_L=750mA	--	10	20	
		I_L=1.5A	--	17	--	
		I_L=3.0A	--	45	--	
Current Limited	Vout=0, Vin=Vout+1V		--	4.5	--	A
Enable Input (TS39301/2/3/4)						
Input Logic Voltage	Low (OFF)		--	--	0.8	V
	High (ON)		2.25	--	--	
Enable Pin Input Current	V_{EN}=2.25V		--	--	75	μA
	V_{EN} =0.8V		--	--	4	
Shutdown Output Current (Note 8)			--	--	20	μA
Adjustable Output (TS39302)						
Reference Voltage			0.980|Vo|	1.24	1.020|Vo|	V

Electrical Characteristics

Flag Output (TS39301)					
Output Leakage Current	V_{OH}=16V	--	--	2	μA
Output Low Voltage (Note 9)	Vin=2.5V, I_{OL}=250uA	--	--	400	mV
Upper Threshold Voltage	% of Vout	--	--	99	%
Lower Threshold Voltage	% of Vout	93	--	--	%
Hysteresis		--	1	--	%

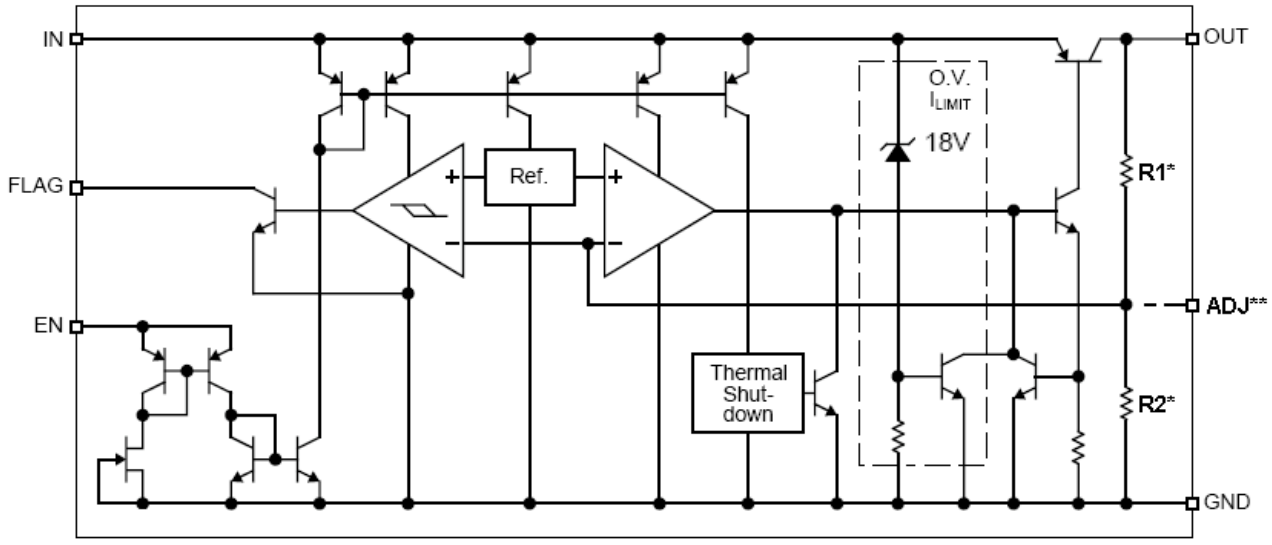
Thermal Performance

Condition	Package type	Typ	Unit
Thermal Resistance Junction to Case	TO-220-5L	2	°C/W
	TO-263-5L	2	

Note 1. Exceeding the absolute maximum ratings may be damaged the device.
Note 2. The device is not guaranteed to function outside its operating rating.
Note 3. Devices are ESD sensitive. Handling precautions recommended.
Note 4. $Pd_{(max)}$ = ($Tj_{(max)}$ - Ta) + Θja, where Θja depends upon the printed circuit layout. See "Applications Information".
Note 5. Output voltage temperature coefficient is ΔVout $_{(worst\ case)}$ + ($Tj_{(max)}$ – $Tj_{(min)}$) where $Tj_{(max)}$ is +125 °C and $Tj_{(min)}$ is -40 °C.
Note 6. Vdrop = Vin - Vout when Vout decreases to 99% of its nominal output voltage with Vin = Vout + 1. For output voltages below 2.5V, dropout voltage is the input-to-output voltage differential with the minimum input voltage being 2.5V. Minimum input operating voltage is 2.5V
Note 7. Ignd is the quiescent current. Iin = Ignd + Iout
Note 8. Ven<0.8V, Vin<8V and Vout=0
Note 9. For 1.8V device, Vin = 2.25V (device is in dropout)

Block Diagram

TS3930x series



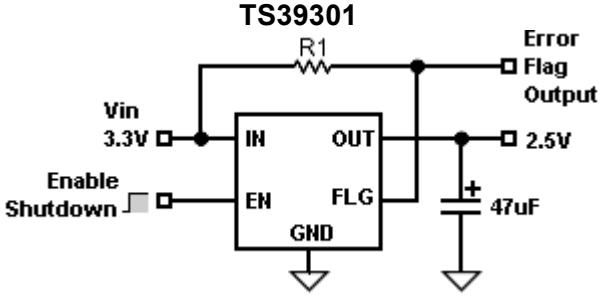
* Feedback network is fixed output versions only (TS39301 & TS39303 & TS39304)
** Adjustable output version only (TS39302)

Pin Assignment

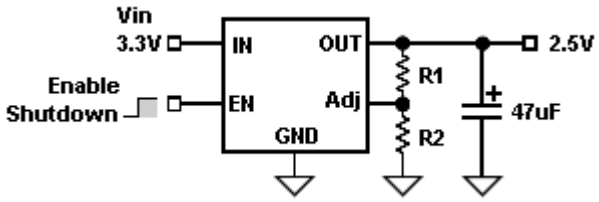
Pin No.				Pin Configuration	Pin Description
TS39301	TS39302	TS39303	TS39304		
1	**1**	**1**	**2**	Enable	TTL/COMS compatible input. Logic high is enable; logic low or open is shutdown
2	**2**	**2**	**1**	Input	Unregulated input: +16V maximum supply
3	**3**	**3**	**3**	Ground	Ground pin and TAB/heatsink are internally connected.
4	**4**	**4**	**5**	Output	Regulator output
5				Flag	Open-collector output. Active low indicates an output fault condition.
	5			Adjust	Feedback input. Connect to resistive voltage-divider network.
		5	**4**	Sense	Sense pin is the input to the error amplifier

Typical Application Circuit

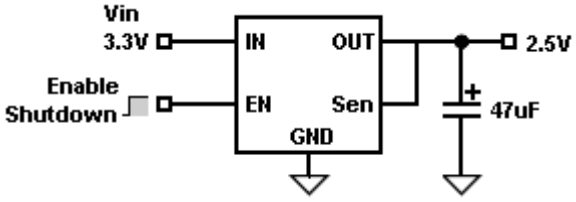
TS39301



TS39302



TS39303 / 4



Application Information

Application Information

The TS39300/1/2/3/4 series are high performance with low dropout voltage regulator suitable for moderate to high current and voltage regulator application. Its 630mV dropout voltage at full load and over temperature makes it especially valuable in battery power systems and as high efficiency noise filters in post regulator applications. Unlike normal NPN transistor design, where the base to emitter voltage drop and collector to emitter saturation voltage limit the minimum dropout voltage, dropout performance of the PNP output of these devices is limited only by low Vce saturation voltage.

The TS39300/1/2/3/4 series is fully protected from damage due to fault conditions. Linear current limiting is provided. Output current during overload conditions is constant. Thermal shutdown the device when the die temperature exceeds the maximum safe operating temperature. Transient protection allows device survival even when the input voltage spikes above and below nominal. The output structure of these regulators allows voltages in excess of the desired output voltage to be applied without reverse current flow.

Output Capacitor Requirement

The TS39300/1/2/3/4 series requires an output capacitor to maintain stability and improve transient response is necessary. The value of this capacitor is dependent upon the output current, lower currents allow smaller capacitors. TS39300/1/2/3/4 series output capacitor selection is dependent upon the ESR of the output capacitor to maintain stability. When the output capacitor is 47uF or greater, the output capacitor should have an ESR less than 1Ω. This will improve transient response as well as promote stability. Ultra low ESR capacitors, such as ceramic chip capacitors, may promote instability. These very low ESR levels may cause an oscillation and/or under damped transient response. A low ESR solid tantalum capacitor works extremely well and provides good transient response and stability over temperature aluminum electrolytes can also be used, as long as the ESR of the capacitor is <1Ω.

The value of the output capacitor can be increased without limit. Higher capacitance values help to improve transient response and ripple rejection and reduce output noise.

Input Capacitor Requirement

An input capacitor of 1uF or greater is recommended when the device is more than 4” away from the bulk AC supply capacitance or when the supply is a battery. Small, surface mount, ceramic chip capacitors can be used for bypassing. Larger values will help to improve ripple rejection by bypassing the input to the regulator, further improving the integrity of the output voltage.

Minimum Load Current

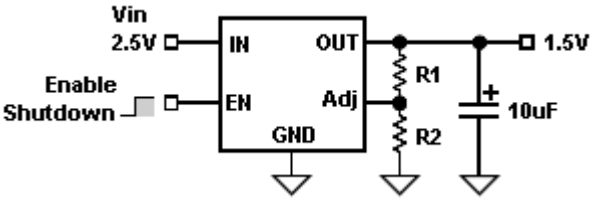
The TS39130/1/2/3/4 series is specified between finite loads. If the output current is too small leakage currents dominate and the output voltage rises. A 10mA minimum load current is necessary for proper regulation.

Adjustable Regulator Design

The adjustable regulator versions (TS39302) is allow to programming the output voltage anywhere between 1.25 and the 16V maximum operating rating of the family.

Two resistors are used. Resistors can be quite large up to 1MΩ, because of the very high input impedance and low bias current of the sense comparator, the resistor values are calculated by:

R1 = R2 * [(Vout / 1.24) – 1]

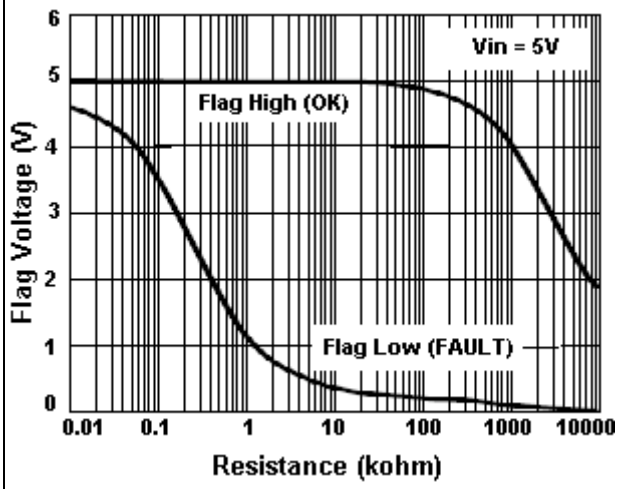


Where Vout is the desired output voltage. Above application circuit shows component definition. Applications with widely varying load currents may scale the resistors to draw the minimum load current required for proper operation.

Application Information (continues)

Error Flag

TS39301 versions feature an Error Flag, which looks at the output voltage and signals an error condition when this voltage drops 5% below its expected value. The error flag is an open-collector output that pulls low under fault conditions. It may sink 10mA. Low output voltage signifies a number of possible problems, including an over-current fault (the device is in current limit) or low input voltage. The flag output is inoperative during over temperature shutdown conditions. A pull-up resistor from error flag to either Vin or Vout is required for proper operation. For information regarding the minimum and maximum values of pull-up resistance, refer the graph as follow:



When the error flag is not used, it is best to leave it open, the error flag pin can be tied directly to output Pin.

Enable Input

TS39301/2/3/4 versions feature an active-high enable (EN) input that allows ON/OFF control of the regulator. Current drain reduces to “zero” when the device is shutdown, with only micro-amperes of leakage current. The EN input has TTL/CMOS compatible thresholds for simple interfacing with logic interfacing. EN may be directly tied to Vin and pulled up to the maximum supply voltage.

Transient Response and 3.3V to 2.5V or 2.5V to 1.8V Conversion

TS39301/2/3/4 has excellent transient response to variations in input voltage and load current.

The device have been designed to respond quickly to load current variations and input voltage variations. Large output capacitors are not required to obtain this performance. A standard 47uF output capacitor, preferably tantalum, is all that is required. Larger values help to improve performance even further.

By virtue of its low dropout voltage, this device does not saturate into dropout as readily as similar NPN base designs. When converting from 3.3V to 2.5V or 2.5V to 1.8V, the NPN based regulators are already operating in dropout, with typical dropout requirements of 1.2V or greater,. To convert down to 2.5V or 1.8V without operating in dropout, NPN based regulators require an input voltage of 3.7V at the very least.

The TS39300 series regulator will provide excellent performance with an input as low as 3.0V or 2.5V respectively. This gives the PNP based regulators a distinct advantage over older, NPN based linear regulators.

Power Dissipation

Determine the power dissipation requirements for the design along with the maximum ambient temperature at which the device will be operated.

Pd = (Vin- Vout) * Iout + Vin * Ignd

The heat sink thermal resistance is determined by:

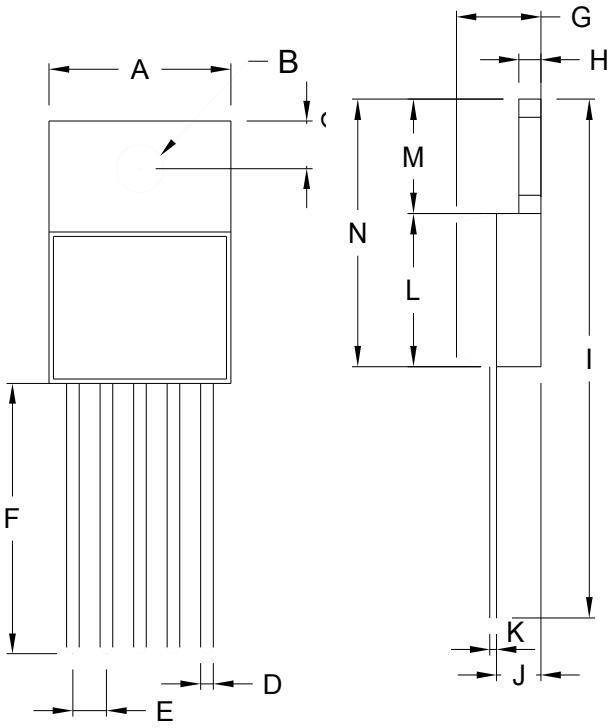
Θsa = [Tj(max) – Ta] / Pd – (Θjc + Θcs)

When Tj(max) < 125 °C, and Θcs is between 0 °C and 2 °C/W, the heat sink may be significantly reduced in applications where the input voltage is known and large compare with the dropout voltage.

Output Sense

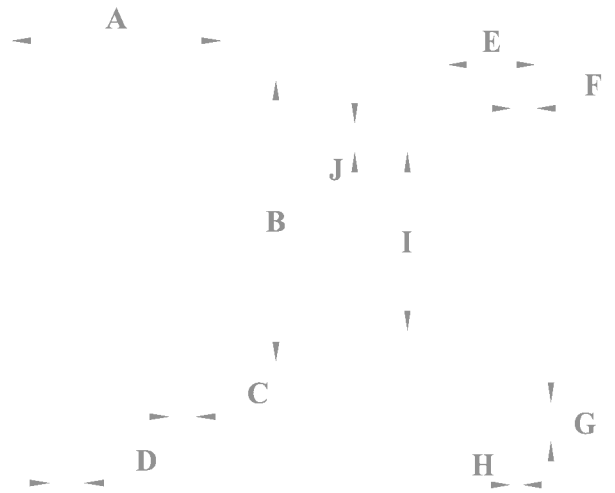
Sense pin can be connect to the load and traces the load voltage, TS39303/4 will adjust the output voltage to maintain the load at expected voltage.

TO-220-5L Mechanical Drawing



TO-220-5L DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.00	10.50	0.394	0.413
B	3.240	4.440	0.128	0.175
C	2.440	2.940	0.096	0.116
D	0.260	1.020	0.010	0.040
E	1.570	1.830	0.062	0.072
F	13.31	14.13	0.524	0.556
G	4.475	5.225	0.176	0.206
H	1.170	1.370	0.046	0.054
I	27.60	29.44	1.087	1.159
J	2.175	2.925	0.086	0.115
K	0.297	0.477	0.012	0.019
L	8.280	8.800	0.326	0.346
M	6.010	6.510	0.237	0.256
N	14.29	15.31	0.563	0.603

TO-263-5L Mechanical Drawing



TO-263-5L DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	10.220	10.260	0.402	0.404
B	14.600	15.870	0.575	0.625
C	0.750	0.770	0.030	0.030
D	1.573	1.827	0.062	0.072
E	4.560	4.570	0.179	0.180
F	1.240	1.270	0.049	0.050
G	2.280	2.790	0.090	0.110
H	0.280	0.320	0.011	0.013
I	8.240	8.280	0.324	0.326
J	1.540	1.800	0.060	0.071